1) Source Issues
2) SLAC's ITF

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SLAC

Present Source Parameters

Parameter	Symbol	Value	Unit
Electrons per micro bunch at source	n_e	$3*10^{10}$	Number
Number of micro bunches	N_e	2820	Number
Micro bunch repetition rate	F_{ub}	3	MHz
Macro bunch repetition rate	F_{mb}	5	Hz
Micro bunch charge at source	C	5	nC
Micro bunch length at source	Δt	1	ns
Peak current in µbunch at source	I_{avg}	5	A
Energy stability	S	< 5	% rms
Electron polarization	Pe	90	%
Photocathode quantum efficiency	QE	0.5	%
Drive laser wavelength	λ	760-800	nm
Micro pulse laser energy	E	5-10	µJ

Minimum bunch length at entrance to first SHB using GPT (Brachmann)

Charge = 6.4 nC

Δt @z=0 m	Δt @z=1.5 m (ps)		
(ps)	120 kV	200 kV	500 kV
2000	2172	2000	
1000	1333	1000	
500	1333	766	500
250	1562	780	312
125	1722	833	250

- SHB1: 216 MHz, $\lambda/4$ = 1157 ns
- Present ILC parameters: 140-160 kV, 5 nC, 1 ns, 1.0 m drift
- Detailed engineering design for drift from gun to SHB1 urgently needed to determine minimum drift distance!

Gun voltage

- Affects **space charge limit** (Child law)

$$j_0 = \left(2.33\times10^{-6}\right)V_0^{3/2}/d^2$$

and

$$j_0' = \left(1.3\times10^{-10}\right)E_{max}^2 \Big/ V_0^{1/2}$$

where *j, V, d, E* in A/cm^2, volts, cm, V/m

- Transit time of single electron from cathode to anode is ~0.3 ns (assuming d=3 cm and β~0.3)
- If r=1 cm (SLC cathode size), then j=1.6 A/cm^2

Gun voltage limitations

ILC | Child law

q	Δt	I	r	j	$r^2\Delta t$	V	d	j_0	E_{max}	j'_0
(nC)	(ns)	(A)	(cm)	(A/cm²)	(cm²ns)	(kV)	(cm)	(A/cm²)	(MV/m)	(A/cm²)
5	1	5	1	1.6	1	140	3	14	8	22
						200		23		19
						350		53		14
			0.5	6.4	0.25					
			0.3	17.8	0.09					
	0.5	10	1	3.2	0.5					
			0.5	12.8	0.12					
			0.3	35.5	0.045					

Note: SLC, Nagoya, JLab-FEL operate at E=8 MV/m

Conclusion: keep $r^2\Delta t > 0.25$

Gun voltage also affects surface charge limit

- With gradient doping, limit not yet determined for pulse beams:
  - 5.5 A/cm^2 measured @ SLAC for 780 nm, 75 ns pulse
  - 9.7 A/cm^2 @ Nagoya for 780 nm, 30 ps
- But nonlinear effects for <0.1 A/cm^2 in cw beams @JLab and elsewhere
- Thus beam size and bunch length at cathode may be required to be large for this reason alone

Cathode 1/e lifetime

For 5 nC pulses, <I>=75 μA

- Lifetime for 100 μA beam with 0.5 mm dia. laser spot
  - 100-200 C → 1×10^5 C/cm^2 (Poelker)
  - 15-30 days for 75 μA
- Lifetime may not scale with laser spot size
  - Conservative estimate for ILC: 60 days
- Reactivation required

Emittance

- Initial emittance determined by beam size and bunch length ($r^2 Dt$)
- Emittance growth determined by gun voltage
- Transport efficiency of beam to subharmonic bunchers affected by beam emittance
- But emittance of bunched beam mostly independent of upstream emittance

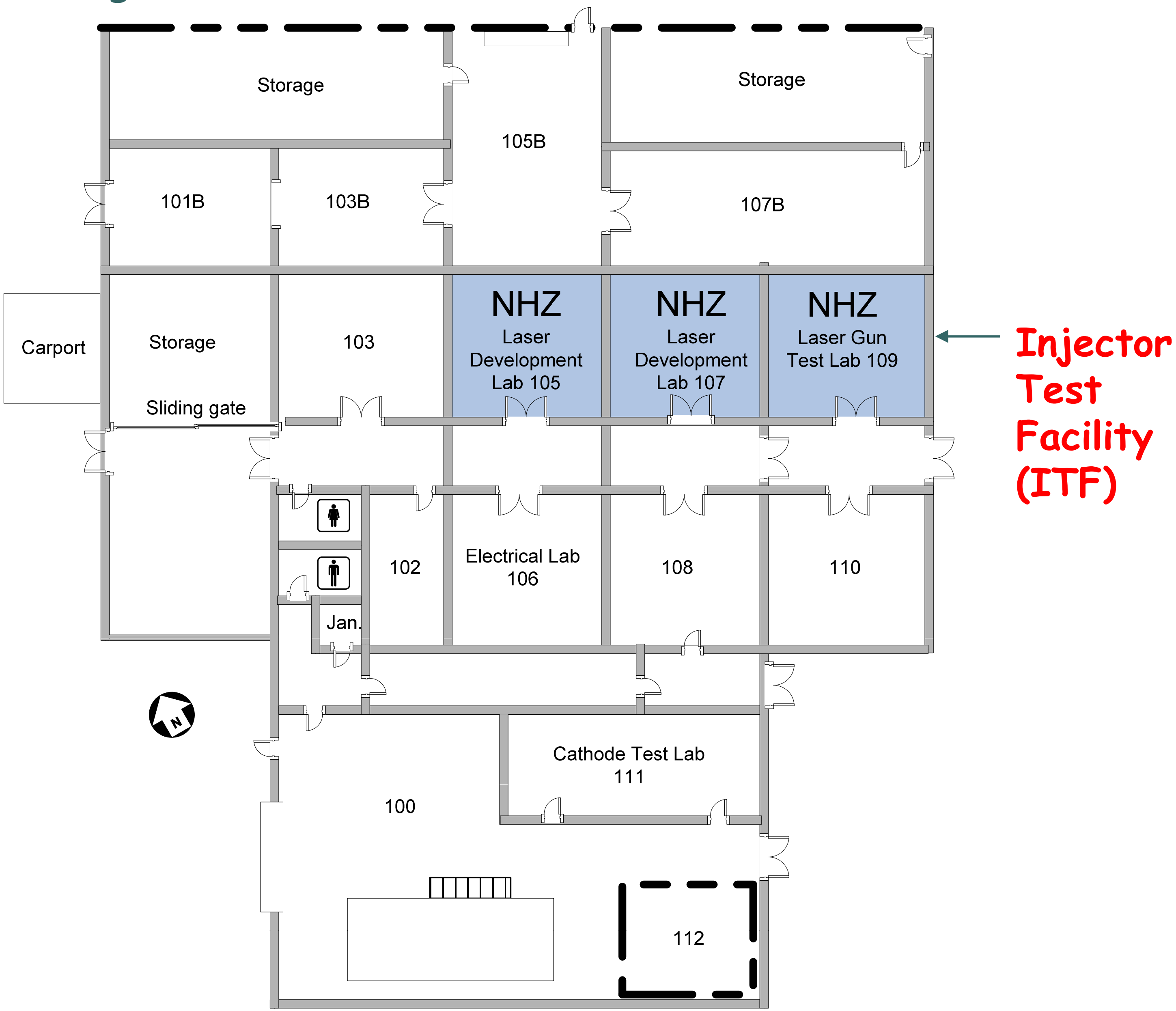
Two-Gun Configuration

- How to manage?
  - Complete instrumentation for both guns (including Mott polarimeters?)
  - Switch guns regularly (every few weeks?)—may make common Mott feasible
  - Need high quality bending magnet that can be rapidly standardized
- Provision for rapid gun replacement (≤8 h) still important
- Remote cesiation (cathode retracted) and remote activation (of working cathode) important
  - Partial retraction for simple cesiation
  - Vacuum isolation for activation

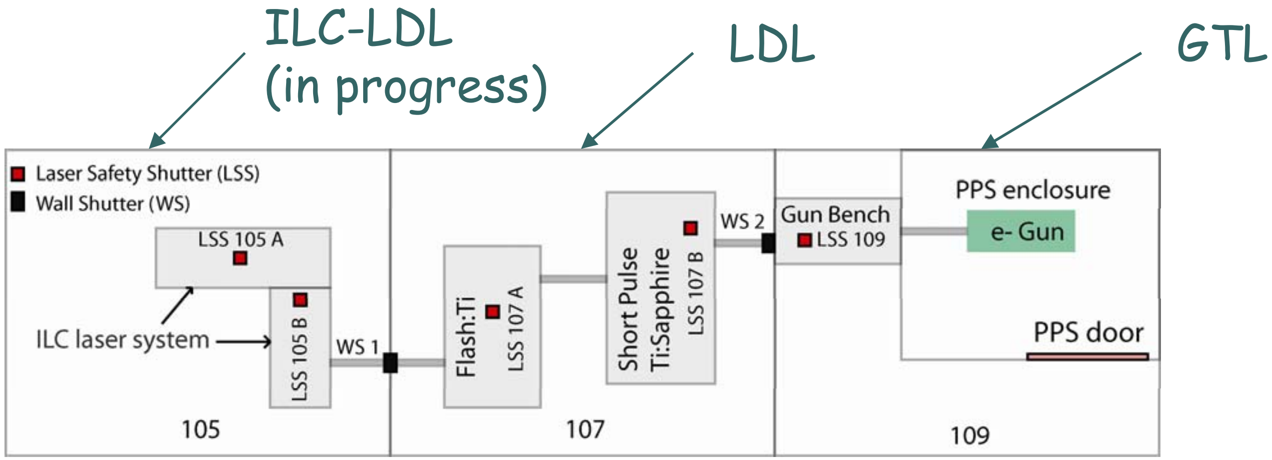
Simulations

- Presently use EGun to model beam in gun
  - EGun has no time dependence
- For gun to accelerator use GPT
- Need 3-D PIC simulations for gun, possibly also for gun to SHB region
- Also need parameter optimization à la Bazarov and Sinclair (PRST-AB, 2005)

Building 006



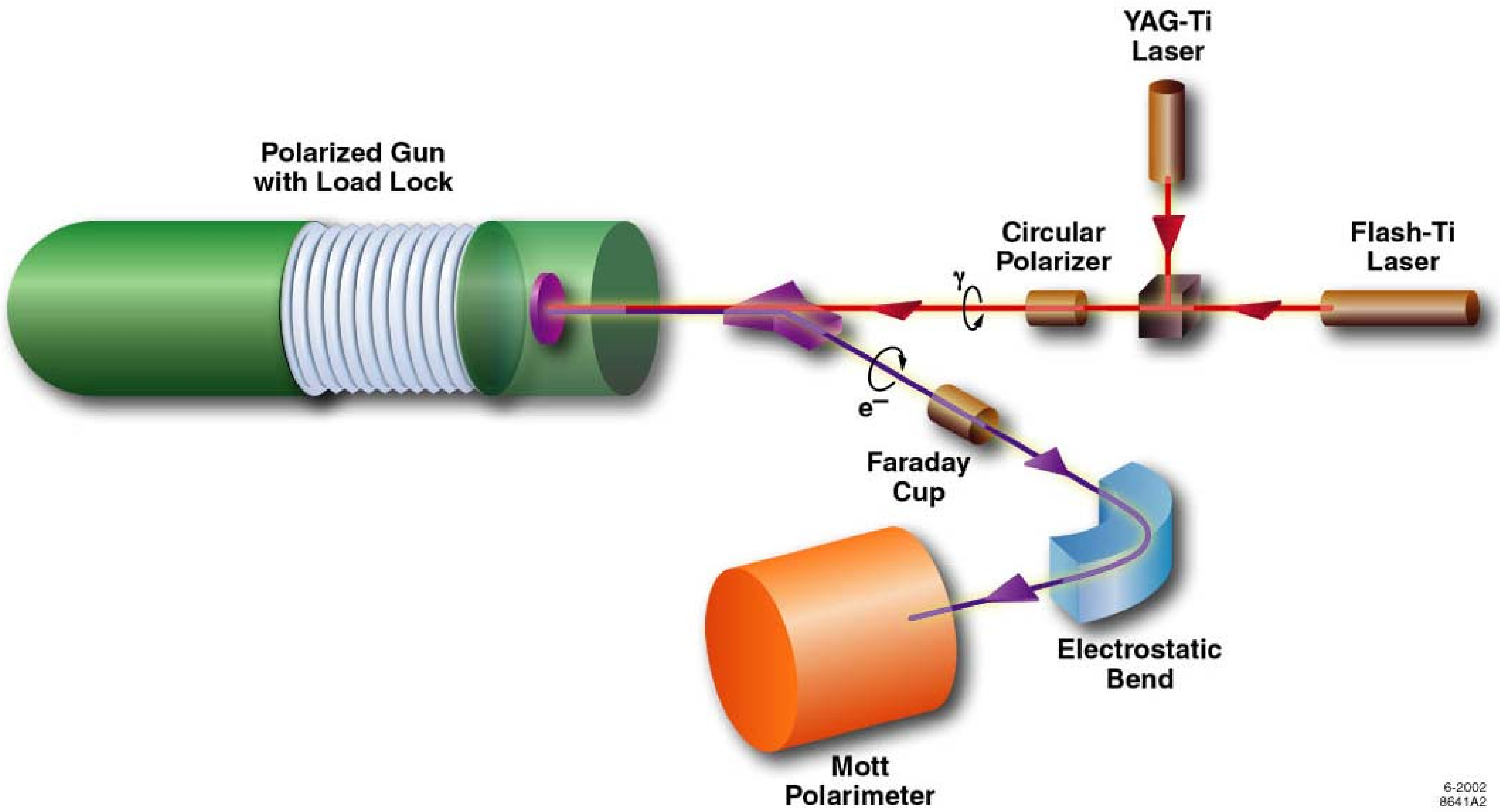
General Layout of ITF



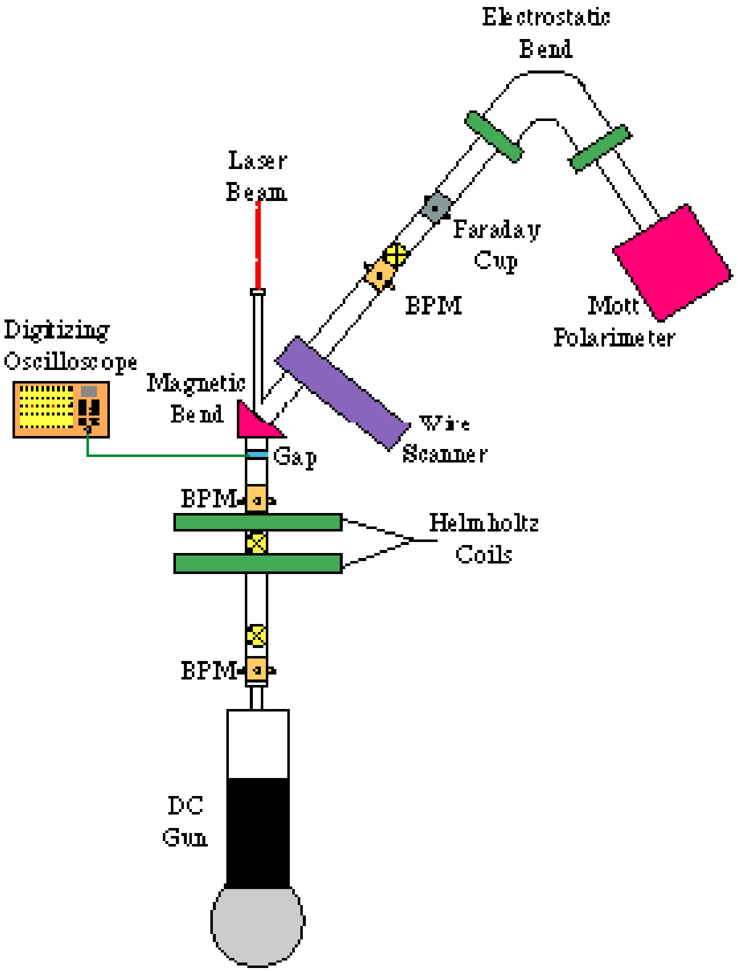
Presently available lasers →

1	Pump Lasers	532 nm	1.8 W	30 mJ	60 Hz
2	YAG-Ti	750-900 nm	12 mW	200 μJ	60 Hz
3	Flash-Ti	750-900 nm	12 W	200 mJ	60 Hz
4	Diode (IIIb)	750 nm	<100 mW		cw
5	Diode (IIIb)	790 nm	<100 mW		cw
6	Diode (IIIb)	833 nm	< 100 mW		cw

Artist's View of ITF System



e^- Beamline in Room 109 (GTL)



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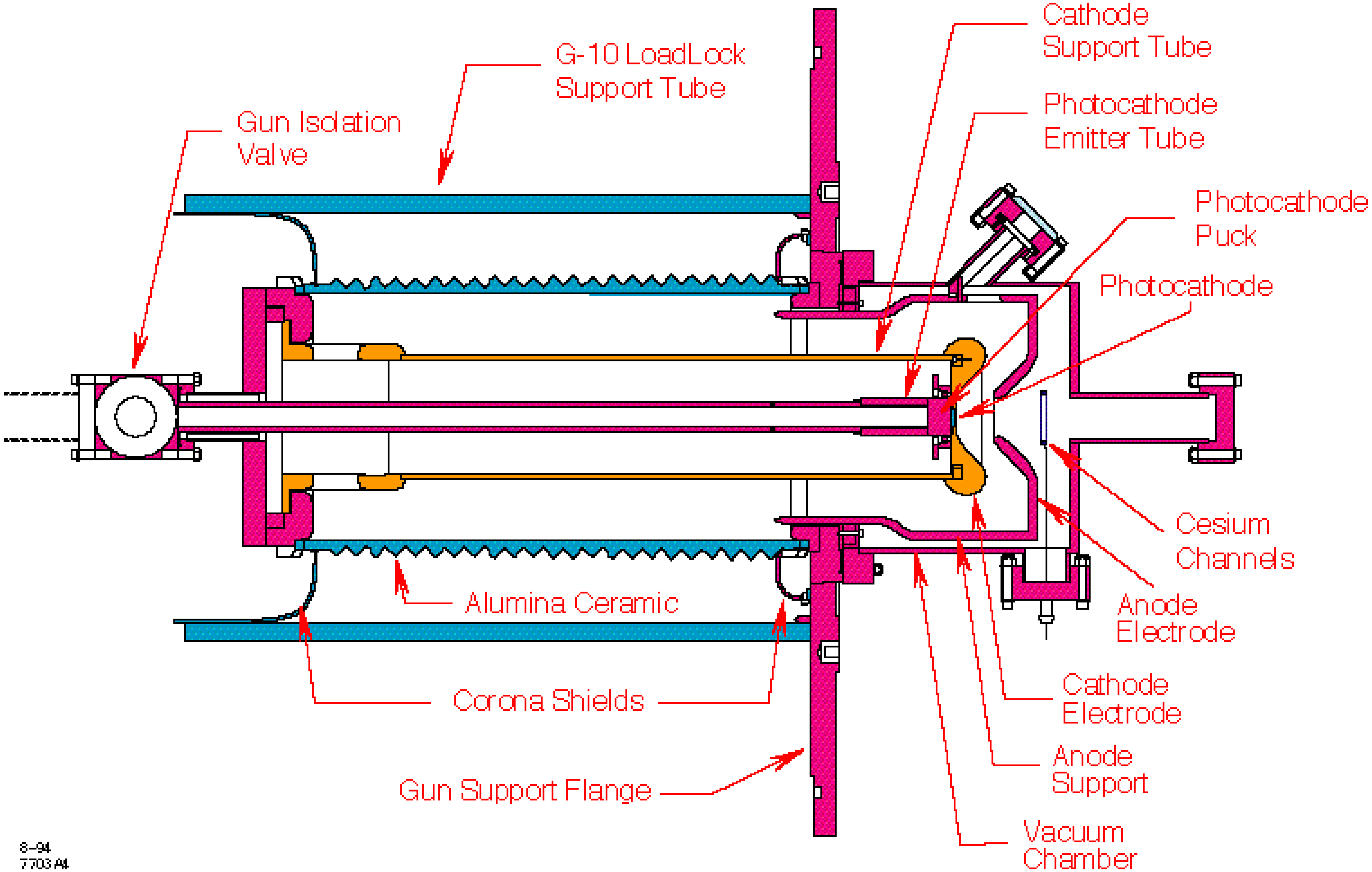
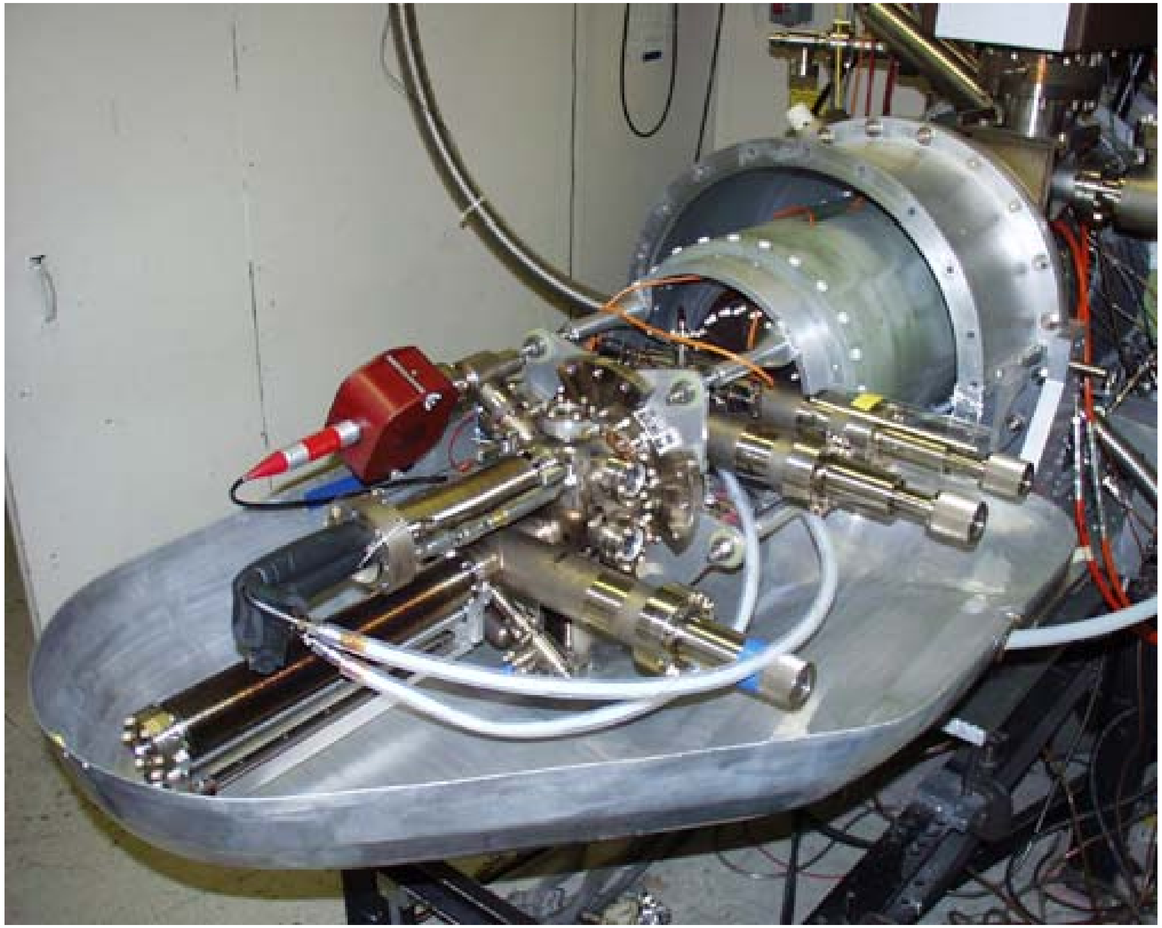
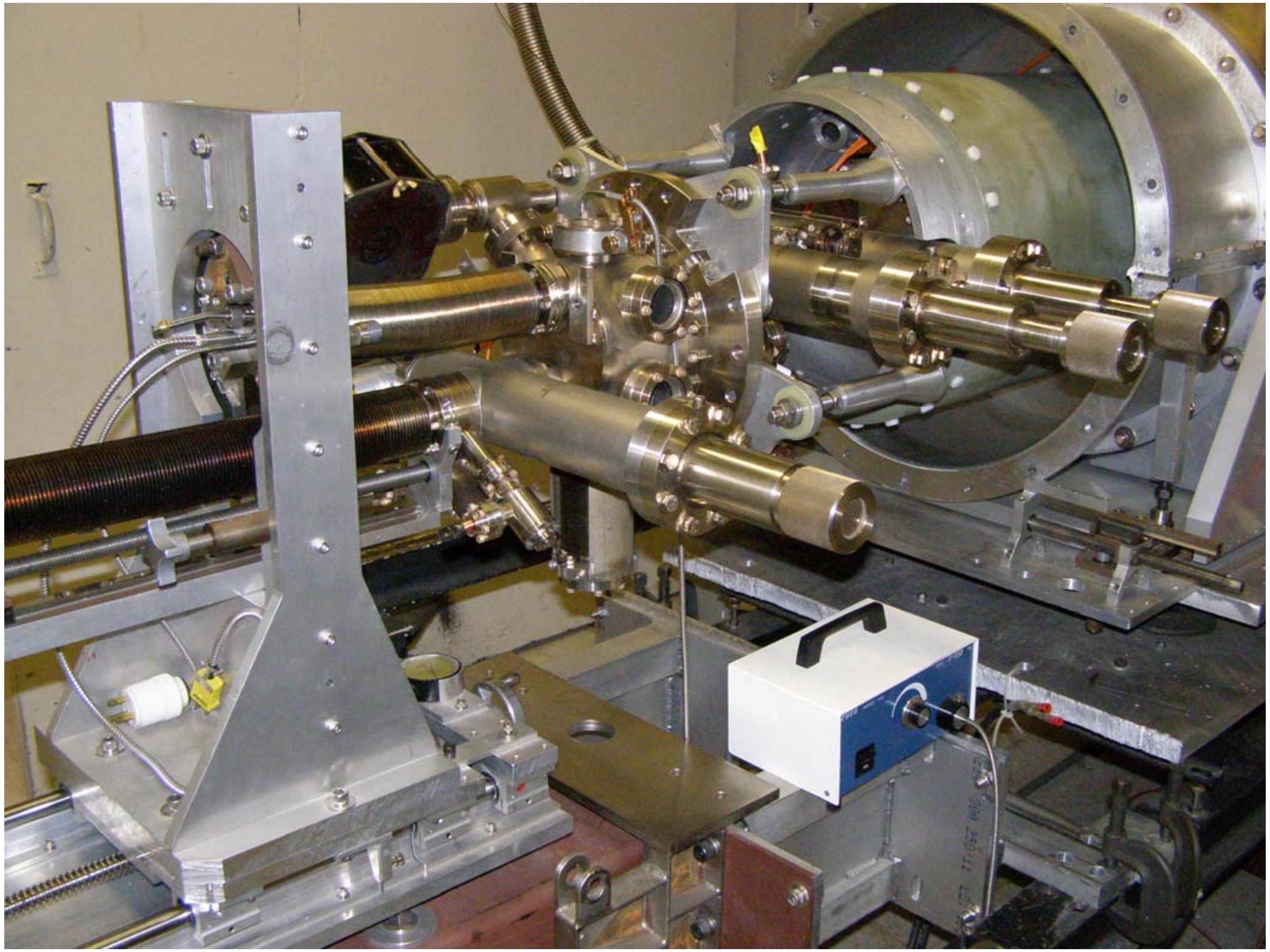
SLAC's Polarized Gun



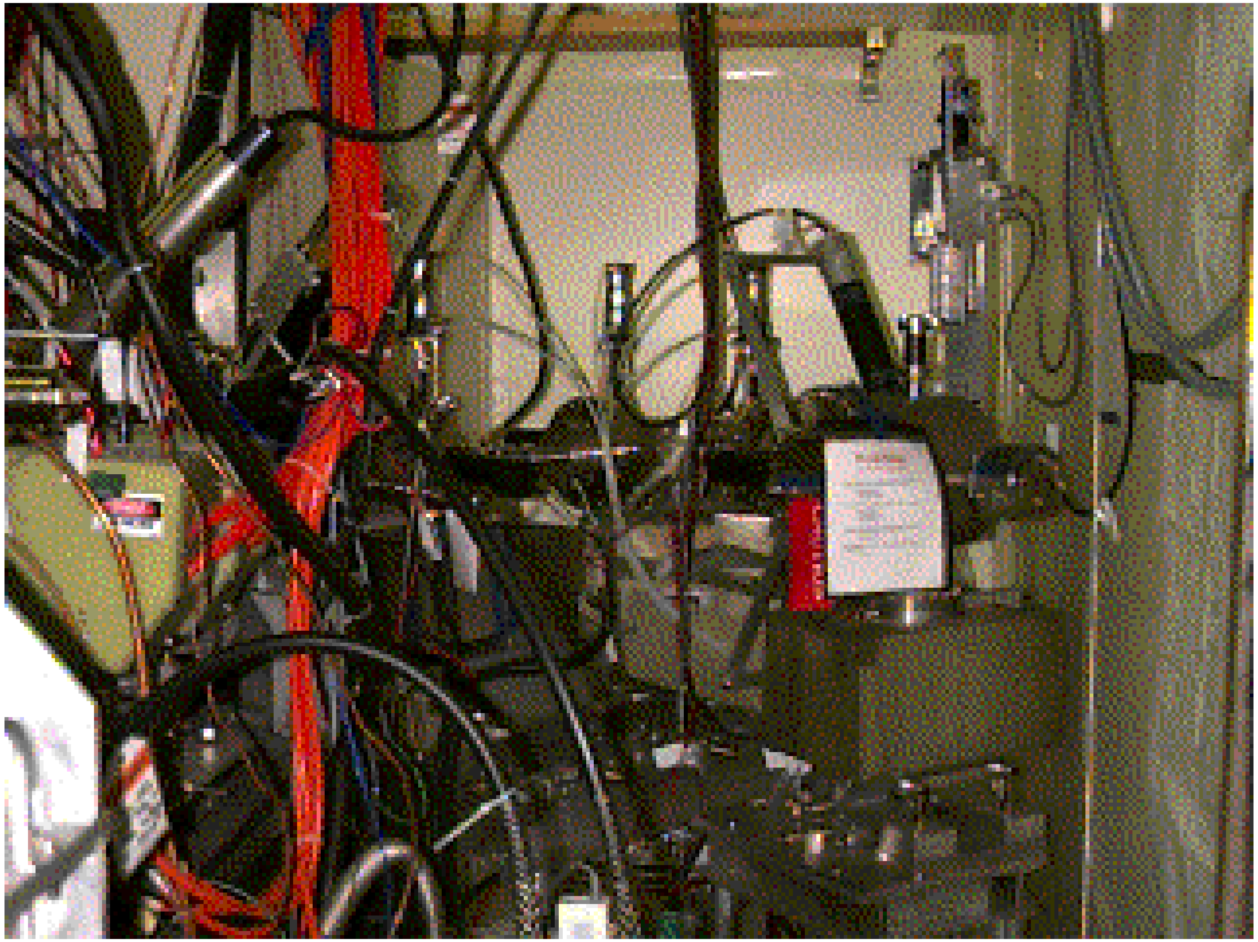
Rear of gun with “clamshell” (corona shield) open revealing isolation valves, prep chamber, cathode support bellows, cathode tray bellows, and optically linked ion pump, cathode cooling lines



Drive mechanism for cathode support tube (shown here in “inserted” state) installed



Looking from gun toward electrostatic bend and (on right) the Mott polarimeter



Plans for ITF

- Immediate plan is to measure surface charge limit for highly-strained AlInGaAs/AlGaAs photocathodes recently grown in St. Petersburg
- Measure Pe and SCL for other R&D photocathodes
- Longer term goal is to demonstrate the ILC pulse train and determine surface charge effects
- System is available for other ILC source R&D projects
  - Test SLC gun with Mo-Ti electrodes?
  - Test other types of guns, such as the SLAC inverted structure gun (which is in storage under vacuum)?